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jc511 U.S. PTO 09/484424 01/18/00

Dear Sir:

Transmitted herewith for filing is the **UTILITY** patent application of:

Inventor(s): Satoru Bushida, et al

Title: APPARATUS FOR LOCKING BENDING MECHANISMS THAT BENDS REFLEX TYPE WAVELENGTH SELECTION ELEMENT

- ☒ 13 pages of written description, claims and abstract.
- ☒ 5 sheet(s) of formal drawings.
- ☒ Executed Declaration and Power of Attorney
- ☐ Assignment Papers (cover sheet and documents)
- ☒ Certified Copy of Priority Documents
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- ☐ Other: ______
- ☒ Filing Fee, calculated as shown below:

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BASIC FEE		
TOTAL CLAIMS	1 - 20 =	0
INDEP. CLAIMS	1 - 3 =	0
☐ MULTIPLE DEPENDENT CLAIMS PRESENTED		

* If the difference in Col. 1 is less than zero, enter "0" in Col. 2.

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	$ 345.00	OR		$ 690.00
x 9	$	OR	x 18	$
x 39	$	OR	x 78	$
+ 130	$	OR	+ 260	$
TOTAL	$ 345.00	OR	TOTAL	$ 690.00

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APPRATUS FOR LOCKING BENDING MECHANISM THAT BENDS REFLEX TYPE WAVELENGTH SELECTION ELEMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element constituting a part of an optical resonator to correct wavefronts in laser beams outputted from the reflex type wavelength selection element.

2. Description of the related Art

Excimer lasers are employed as light sources in steppers for use in semiconductor device manufacture.

Fig.6 is a diagram schematically illustrating a whole configuration of an optical resonator 13 used in an excimer laser.

As shown in Fig.6, a laser chamber 14 of the optical resonator 13 has discharge electrodes 15 which are made up of an anode and a cathode arranged opposite to each other in the direction perpendicular to the paper surface of the drawing. The laser chamber 14 contains laser gas composed of halogen gas, rare gas, buffer gas, etc., which is excited by discharge between the discharge electrodes 15 to generate laser oscillation.

The laser chamber 14 has two laser output ports which are provided with windows 16. Also, slits 19 for restricting the width of the laser beam are provided between the laser chamber 14 and a front mirror 17 and between the laser chamber 14 and a band-narrowing module 18.

The band-narrowing module 18, in this case, comprises a beam expander 20 and a grating 1 serving as an angle dispersing type wavelength selection element. The beam expander 20 is composed of one or more prisms

not shown and expands the beam width of the incident laser beam to output it to the grating 1.

That is, in Fig.6, the optical resonator is configured between the front mirror 17 and the grating 1.

In the construction shown in Fig.6, a laser beam generated in the laser chamber 14 comes into the band-narrowing module 18 wherein the beam expander 20 expands its beam width. Further, the expanded laser beam L comes into the grating 1 to be diffracted, whereby only a predetermined wavelength component of the laser beam comes out of the grating 1 and is returned in the same direction as the incident laser beam. The laser beam returned by the grating 1, after having its width reduced by the beam expander 20, comes into the laser chamber 14. Namely, the grating 1 serves as a reflex type wavelength selection element that reflects a laser beam and selects a wavelength.

The laser beam amplified through passing inside the laser chamber 14 comes into the front mirror 17, whereby a part thereof is extracted as the output beam and the remainder is again returned into the laser chamber 14 and amplified.

Due to various causes, the laser beam wavefront comes to have divergence (expansion) and curvature inside the optical resonator.

For example, in case that the slit 19 is arranged in the optical resonator 13 as described above, the light having passed through the slit 19 becomes a spherical wave due to the diffraction produced at the slit 19.

Further, the aberration of optical elements arranged in the optical resonator 13 might cause the wavefront to be distorted. For example, a transmission type optical element such as the prism expander 20 used as a band-narrowing element has such properties as follows,

(a) the internal refractive index distribution is not perfectly uniform, and

(b) the polished surfaces of the prism are distorted.

Due to these properties, the wavefront of the laser beam having passed through the above-mentioned type optical element comes to have either convex or concave curvature.

When the laser beam L whose wavefront has such curvature comes into the flat grating 1, the wavelength selectivity of the grating 1 lowers. Specifically, when the incident wavefront of the laser beam L on the grating has curvature, the laser beam L comes into respective grooves of the grating 1 at different angles, whereby the wavelength selectivity of the grating 1 lowers.

In a conventional art, the above-mentioned problems have been coped with by bending the grating 1 itself according to the curvature of the incident wavefront on the grating so as to coincide with the wavefront of the laser beam coming into the grating.

Fig.7A and 7B show the conventional art mentioned above.

As shown in Fig.7A and 7B, the grating 1 is provided with supporting members 9 for supporting its both end portions, a holding member 21 for holding its center portion, and a bending mechanism (pushing member 2, spring 3) for moving the center portion of the grating 1 in the pushing and pulling directions through the hold member 21. The bending mechanism can bend the grating 1 in any degree (or can correct the degree of bend).

More particularly, as shown in Fig.7A, when the wavefront is concave viewed from the traveling direction of the incident laser beam L, the center portion of the grating 1 is moved in the incident direction X1 via the holding member 21, whereby the incident surface of the grating 1 becomes convex. On the other hand, as shown in Fig.7B, when the wavefront is convex viewed from the traveling direction of the incident laser beam L, the center portion of the

grating 1 is moved in the converse direction X2 to the incident direction via the holding member 21, whereby the incident surface of the grating 1 becomes concave.

As the pushing mechanism, a micrometer was used so that the grating 1 precisely is bent in nanometer level.

In such conventional art, since the grating 1 is bent with high precision at nanometer level of measurement, even a very small displacement in bending is not allowed. Accordingly, once laser devices are produced at a factory and the grating has been bent and adjusted, it is necessary not to permit any displacement of the bend from an adjusted position.

However, the configuration of the grating may easily be changed by vibrations and shocks generated during the transportation of the laser devices.

For this reason, there is a problem that the configuration of the grating that has been bent by using a micrometer with high precision cannot be maintained.

Thus, the configuration of the grating does not correspond to the curvature of the incident wavefront on the grating, so that the wavelength selection performance lowers.

SUMMARY OF THE INVENTION

In view of the foregoing, an object of the present invention is to stabilize the wavelength selection performance in a reflex type wavelength selection element.

To achieve this object, according to the present invention, there is provided an apparatus for locking a bending mechanism that bends a reflecting surface of a reflex type wavelength selection element constituting a part of a optical resonator according to curvature of wavefront of an incident laser beam,

characterized in that locking means for locking the bending mechanism is provided.

According to the present invention, as shown in Fig.1, locking means 8 locks a bending mechanism 2. Accordingly, the configuration of the reflex type wavelength selection element 1 that has been bent by the bending mechanism 2 corresponding to the curvature of the wavefront of an incident laser beam L is maintained. Therefore, after the shipment of the laser devices from a factory, it is possible to prevent the adjusted position of the bent configuration of the grating 1 from being displaced.

Accordingly, it is possible to stabilize the performance of wavelength selection in the reflex type wavelength selection element 1, even though the laser device receives vibration and shock.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and features of the present invention will be seen by reference to the description taken in connection with the accompanying drawings in which:

Fig.1 is a diagram schematically illustrating a first embodiment of an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element of the present invention;

Fig.2 is a diagram schematically illustrating a second embodiment of an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element of the present invention;

Fig.3 is a perspective view of the pushing member shown in Fig.1;

Fig.4 is a diagram illustrating a modification to the embodiment shown in Figs.1 and 2;

Fig.5 is a diagram illustrating a modification to the embodiment shown

in Figs.1 and 2;

Fig.6 is a diagram schematically illustrating the constitution of the optical resonator of the laser device wherein the embodiment of the apparatus is built; and

Figs.7A and 7B are diagrams schematically illustrating the reflecting surfaces of the gratings that are bent according to curvatures of wavefronts of laser beams.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element will be described with reference to the accompanying drawings.

Fig.1 shows a first embodiment of an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element. Besides, in Fig.1, constitutional elements that are identical with corresponding elements in Figs.6 and 7 described above are given the same reference numbers and therefore, the explanation about those constitutional elements is omitted.

Fig.1 shows a side view in section of the apparatus according to the embodiment.

A grating 1 is a reflex type wavelength selection element constituting one side of the optical resonator 13. The reflecting surface of the grating 1 where the laser beam L comes into is so constructed that it can be bent by pushing and pulling according to the curvature of the wavefront of the laser beam L. That is, as shown in Figs.7A and 7B, a grating-supporting member 9 supports both end portions of the grating 1. A holding member 21 holds the center portion of the grating 1. The grating-supporting member 9 pushes the top end of the grating 1 through a grating-supporting spring 10, thereby fixing

the grating 1 to a lower supporting member 7.

The bending mechanism that bends the grating 1 is constructed as follows:

The bending mechanism comprises a pushing member 2 which moves the center of the grating 1 in the pushing and pulling directions via the holding member 21, springs 3 and 4, and adjusting bolt 5.

More specifically, the bending mechanism 2, 3, 4, 5 comprises the springs 3 and 4 that are connected to the holding member 21 at one ends and connected to the pushing member 2 at the other ends, the adjusting bolt 5 that is screwed into the lower supporting member 7 in such a way that the head of the bolt faces downward and the top of the bolt contacts the slant portion K of the pushing member 2, and the pushing member 2 that slides in the direction X1, X2 bending the reflecting surface of the grating 1 by changing of the position where the top end of the bolt 5 contacts the slant portion K, according to direct-moving of the adjusting bolt 5 in the direction of arrows Y1, Y2.

The pushing member 2 slides between an upper supporting member 6 and the lower supporting member 7. Fig.3 shows a perspective view of the pushing member 2. The surfaces A, B where the pushing member 2 is in contact with the upper supporting member 6 and the lower supporting member 7 are finished surfaces with small coefficient of friction.

The adjusting bolt 5 is screwed into the lower supporting member 7 in such a way that the head of the bolt is adjustable by turning from lower side.

In this embodiment, a locking screw 8 is screwed into the lower supporting member 7. The locking screw 8 locks the pushing member 2 located between the upper supporting member 6 and the lower supporting member 7. The locking screw 8 is screwed in such a way that the head of the screw 8 is adjustable by turning from lower side and the top of the screw 8

contacts the lower surface of the pushing member 2.

Hereinafter, the operation of the embodiment is explained.

First of all, the reflecting surface of the grating 1 is bent by the bending mechanism 2, 3, 4, 5.

Specifically, as shown in Fig.7A, it is supposed that the wavefront of the laser beam L is concave, when viewed from the traveling direction of the incident laser beam L. In this case, the head of the adjusting bolt 5 is turned in the clockwise direction, whereby the adjusting bolt 5 directly moves upward in the direction Y1 in Fig.1. Thereupon, the contacting position between the top portion of the adjusting bolt 5 and the slant portion K of the pushing member 2 moves upward, whereby the pushing member 2 slides in the left direction X1 in Fig.1. As a result, the center of the grating 1 moves in the incident direction X1 namely pushing direction through the holding member 21, so that the incident surface of the grating 1 is configured so as to be convex. After that, when the pushing member 2 slides to the position where corresponds to the curvature of the wavefront of the laser beam L that goes into the reflecting surface of the grating 1, the adjustment of the adjusting bolt 5 is completed.

On the other hand, as shown in Fig.7B, it is supposed that the wavefront of the laser beam L is convex, with viewed from the traveling direction of the incident laser beam L. In this case, the head of the adjusting bolt 5 is turned in the counterclockwise direction, whereby the adjusting bolt 5 directly moves downward in the direction Y2 in Fig.1. Thereupon, the contacting position between the top portion of the adjusting bolt 5 and the slant portion K of the pushing member 2 moves downward, whereby the pushing member 2 slides in the right direction X2 in Fig.1. As a result, the center of the grating 1 is moved in the opposite direction X2 to the incident direction by spring force of the springs 3, 4 through the holding member 21, so that the

incident surface of the grating 1 is configured so as to be concave. After that, when the pushing member 2 slides to the position where corresponds to the curvature of the wavefront of the laser beam L that goes into the reflecting surface of the grating 1, the adjustment of the adjusting bolt 5 is completed.

As described above, after the adjustment by the adjusting bolt 5 is completed, the head of the locking screw 8 is screwed. This allows the top portion of the locking screw 8 to be in contact with the lower surface of the pushing member 2 to lock the pushing member 2.

As described above, according to the embodiment, since the pushing member 2 is locked, it is possible to maintain the configuration of the grating 1 that was bent by the pushing member 2 according to the curvature of the wavefront of incident laser beam L. For that reason, after the shipment of the laser devices from a factory, it is possible to prevent the adjusted position of the bent configuration of the grating 1 from being displaced. Accordingly, it is possible to stabilize the performance of wavelength selection in the grating 1 even though the laser device receives vibration and shock. Besides, in this embodiment, the locking of the pushing member 2 with the screw 8 maintains the adjusted configuration of the grating 1. However, the locking of the adjusting bolt 5 by locknut and the like may maintain the adjusted configuration of the grating 1. Also, without screws, locknuts and the like, bonding and the like may fix the pushing member 2.

Besides, after the adjustment of the adjusting bolt 5 is completed and the locking screw 8 locks the pushing member 2, the adjusting bolt 5 may be removed.

Fig.2 shows an alternative embodiment relative to that shown in Fig.1. Besides, in Fig.2, constitutional elements that are identical with corresponding elements in Fig.1 described above are given the same reference numbers and

therefore, the explanation about those constitutional elements is omitted.

In the apparatus of the embodiment shown in Fig.2, a micrometer 12 is used in place of the adjusting bolt 5 in Fig.1. Specifically, the micrometer 12 is mounted to the lower supporting member 7 in such a way that its operating portion faces downward and its top contacts the slant portion K of the pushing member 2. Accordingly, the micrometer 12 is adjustable by turning from lower side.

Further, a locking screw 11 which locks the pushing member 2 from upper side is used in place of the locking screw 8 which locks the pushing member 2 from lower side shown in Fig.1. That is, the locking screw 11 is screwed into the upper supporting member 6 so as to lock the pushing member 2 between the upper supporting member 6 and the lower supporting member 7. The locking screw 11 is screwed in such a way that the head of screw is adjustable by turning from upper side and the top of screw contacts the upper surface of the pushing member 2.

Consequently, in the embodiment shown in Fig.2, the pushing member 2 slides by turning of the micrometer 12, whereby the reflecting surface of the grating 1 is bent so as to become a configuration according to the curvature of the laser beam L.

Further, after the adjustment of the micrometer 12 is completed, the pushing member 2 is locked by the locking screw 11. Accordingly, in the embodiment shown in Fig.2, like the embodiment shown in Fig.1, it is possible to stabilize the performance of wavelength selection in the grating 1 even though the laser device receives vibration and shock.

Besides, in the embodiments described above, screws 8, 11 lock the pushing member 2. However, as shown in Fig.4, plate members C and D may be employed to lock the pushing member 2 from the upper side, lower side, or

both sides.

Also, as shown in Fig.5, plate members G and H may be employed to lock the pushing member 2 from one lateral side, the other lateral side, or both lateral sides. Further, all surfaces including the upper and lower sides and the both lateral sides on the pushing member 2 may be locked.

It is further understood by those skilled in the art that the foregoing description is a preferred embodiment of the present invention and that various changes and modifications may be made in the present invention without departing from the spirit and scope thereof.

WHAT IS CLAIMED IS:

1. An apparatus for locking a bending mechanism that bends a reflecting surface of a reflex type wavelength selection element constituting a part of a optical resonator according to curvature of wavefront of an incident laser beam, characterized in that:

locking means for locking the bending mechanism is provided.

ABSTRACT OF THE DISCLOSURE

A an apparatus for locking a bending mechanism that bends a reflex type wavelength selection element for a bending mechanism that bends a reflex type wavelength selection element comprises a locking assembly. The locking assembly locks the bending mechanism. This allows maintaining the configuration of the reflex type wavelength selection element with the element being bent by the bending mechanism according to curvature of wavefront of an incident laser beam. Therefore, it is possible to stabilize the performance of wavelength selection in the reflex type wavelength selection element, even though the laser device receives vibration and shock.

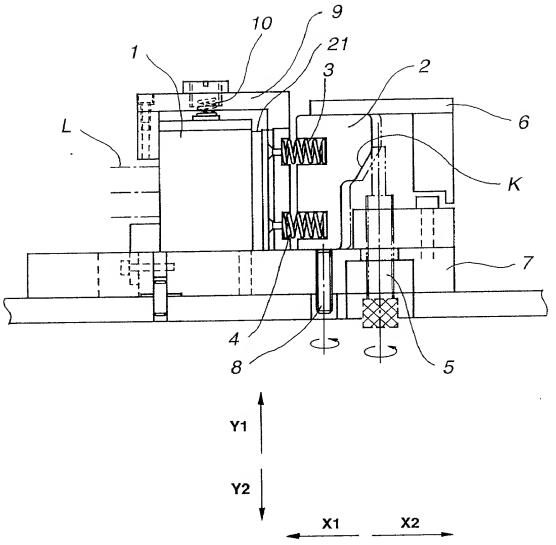


FIG.1

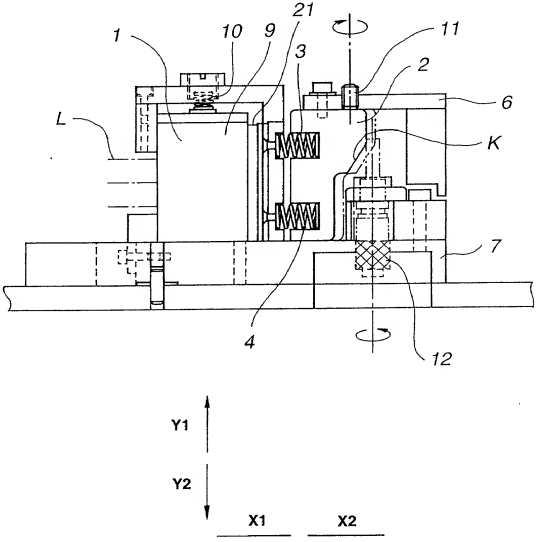


FIG.2

FIG.3

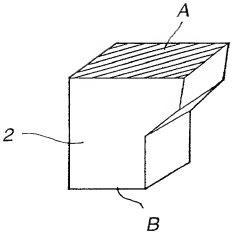


FIG.4

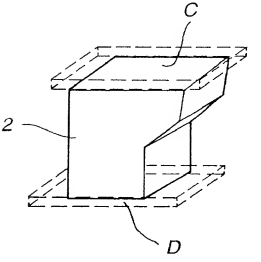
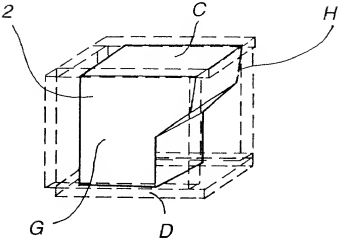


FIG.5



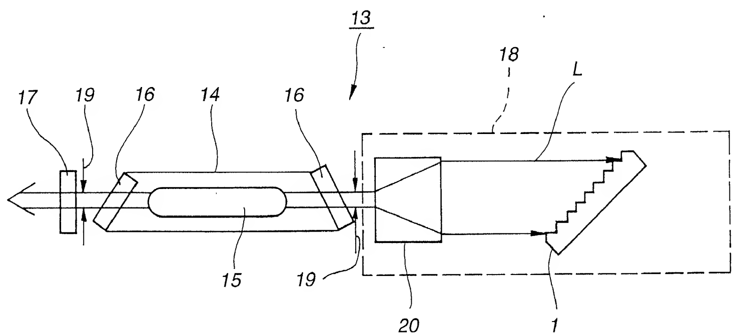


FIG.6
PRIOR ART

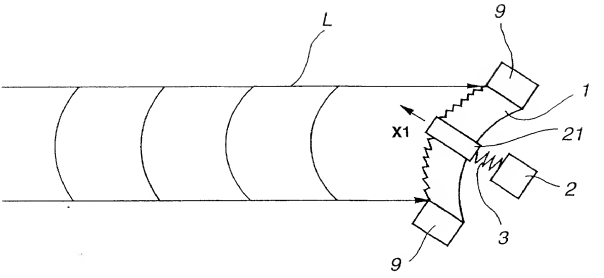


FIG.7A
PRIOR ART

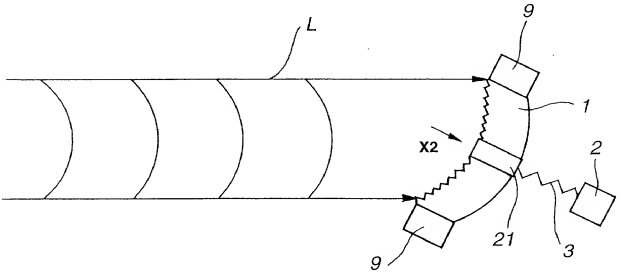


FIG.7B
PRIOR ART

PTO/SB/105 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

APPARATUS FOR LOCKING BENDING MECHANISM THAT BENDS REFLEX TYPE WAVELENGTH SELECTION ELEMENT

上記発明の明細書（下記の欄でX印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ _月_日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
_____ and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration
(日本語宣言書)

私は、米国法典第３５編１１９条(a)-(d)項又は３６５条(b)項に基き下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約３６５(a)項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
10652/ 1999	Japan	19/ January/ 1999	☐
			☐

私は、第３５編米国法典１１９条(e)項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条(c)に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

PTO/SB/106 (8-96)
Approved for use through 9/30/98. OMB 0651-0032
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Japanese Language Declaration
(日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。（弁護士、または代理人の氏名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

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